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Method of operating a machine for the manufacture and/or refinement of material webs

The invention relates to a method for the operation of a machine for the manufacture and/or refinement of material webs, in particular paper webs. The invention relates moreover to a measurement system for the carrying out of such a method.

Such machines, for example paper making machines, consists of a plurality of different machine sections of which at least some are in turn subdivided into further part sections. Each machine section or part section influences the quality of the finished product, for example of a paper web. It is possible to influence the manufacturing process by appropriate control and regulation of individual machine components forming the respective machine section or part section. The large number of possibilities of adjustment makes it difficult to determine the influence of changes which are made at individual machine components on the ability of the respective machine section or part section to function or on the quality of the finished product.

It is known to carry out moisture content, thickness and weight per unit area measurements following the dryer section of a paper making machine, for example before the roller, and to use these measurements for the control, regulation and optimisation of the process control. It is known, simply for the determination of the moisture content of the paper, to carry out measurements at the start of the dryer section, continuously, regularly - i.e. taking place at specific or process-dependent intervals - or

in the short term. Furthermore it is known to carry out continuous, regular or short-term measurements in the steam system and condensate system of the dryer section and to use these measurements for the control and regulation of the process, with the pumps and switch-off valves simply being controlled in the main steam line which leads to the dryer section.

Known apparatuses and methods are for example described in "Das Papier" (The Paper) no. 12, 1995, p.771-775, in "TAPPI Proceedings 1992 Engineering Conference", p.629-638 and also p.639-654 and in "Pulp & Paper Canada", 98:12(1997), p.111-113. A measuring system for the determination of the moisture content of a fibre material web is known from the German patent application 19844927.5 with the filing date 30/09/1998, in which the measurement takes place where the fibre web lies on a substantially water-free, co-moving surface. A known apparatus for the measurement of, for example, the moisture content of a paper web is the instrument "INFRAGAUGE PRO" of the company Infrared Engineering.

The problem (object) underlying the invention is to provide a method and also a measuring system of the initially named kind with which a picture can be obtained of the manufacturing process as accurately as possible, in particular in a paper making machine, and which in particular enables changes to be made in the manufacturing process for its optimisation or change in targeted manner.

This object is satisfied by the features of claim 1 and in particular in that process data concerning at least one measured parameter which relates to

a manufacturing process are detected and jointly evaluated in the region of at least one machine section, in particular of the dryer section of a paper making machine, with the detection of the process data taking place at a plurality of measurement zones which are arranged in series in the process direction.

The invention makes it possible to obtain many pieces of information concerning the manufacturing process, at least with respect to the respective machine section. In this way, a substantially more accurate picture of the process or process section results which enables a better understanding of the influence of the individual machine components on the manufacturing process in a complex machine, such as, for example, in a paper making machine. The provision of a plurality of measurement zones arranged in series, which can each include several individual measurement positions, makes it possible to obtain information from such positions of the machine through which the material web moves in time sequence. Thus, for example, by measuring the moisture content of a paper web moving through a dryer section of a paper making machine, the time-dependent course of drying, and thus the influence of the individual components of the dryer section on the paper web can be investigated in detail. The joint evaluation of the process data detected at the individual measurement zones arranged in series enables an integrated consideration of all measurements and serves in this manner for an improved understanding of the respective machine section. By taking account of the web speed or process speed, individual points on the material path can be followed on their route through the respective machine section. The time-dependent course of the respectively investigated measured parameter can thus be found with a high accuracy. By providing a large number of measurement zones

arranged in series and/or by interpolation between the individual process data obtained at measurement zones spaced apart in the process direction it is thus possible to obtain continuous or quasi continuous longitudinal profiles of the respective measured parameter. Furthermore, the process data found in accordance with the invention can be used for the formation and/or the optimisation of mathematical models which at least describe the respective machine section. Since, in accordance with the invention, the respective measured parameter can be obtained spatially resolved in the process direction, as a result of the measured zones being arranged in series, disturbances, for example as a result of defective machine components, for example of a dryer cylinder, can be precisely localised. This enables faults to be overcome considerably more quickly.

In accordance with a preferred embodiment of the invention, the detection of process data takes place at least substantially simultaneously with respect to at least some measurement zones.

In this way, a large quantity of data is simultaneously available concerning different zones of the machine so that the data can be simultaneously evaluated directly following its detection. Through the use of fast computers, rapid on-line control or regulation of the machine can be carried out on the basis of established data.

In accordance with a further preferred embodiment of the invention, the detection of process data takes place in the vicinity of part sections in which machine settings can be changed, in particular by control and/or regulation of machine components.

Thus, by way of example, a measurement zone or a measurement position can be provided directly after a dryer system or of a group of dryer cylinders in the process direction, so that the influence of changes in the settings of the dryer cylinder or cylinders can be read off from the process data and can consequently be recognised at once. By providing a closed regulating circuit, the relevant machine section or part section can as a consequence by ideally set up in the shortest possible time. It is also possible to provide a measurement zone or a measurement location directly before the respective machine section or part section or before a specific machine component, in order to allow the initial conditions prevailing directly in front of this section to enter into the assessment of the respectively investigated section.

In accordance with a further preferred embodiment of the invention, process data are detected concerning a plurality of different measured parameters.

In this way, the manner of operation of the respective machine section or part section can be pictured in a more detailed manner through the process data that is obtained, so that - if necessary - action can be taken in the manufacturing process in a more differentiated manner. The data detection of the different measured parameters preferably also takes place at least substantially simultaneously in order to obtain a fast and accurate overview of the machine with respect to the investigated section or sections.

In a preferred variant, process data concerning measured parameters are detected which relate to the machine, the material web and to the environment.

At least all the important parameters through which the quality of the finished product can influenced in some way or other can be subjected to an integrated consideration and assessment through the joint evaluation of the process data in order to set up the machine in such a way that it is ideally matched to the respectively prevailing conditions with respect to the respectively desired characteristics of the material web.

One measurement parameter can relate to a characteristic paper parameter of a paper web, for example the moisture content, the temperature, the weight per unit area, the thickness, various surface characteristics, the shrinkage behaviour, the air permeability, the extensibility of the paper, the tear length, the load at fracture, the tensile strength, the fibre orientation or the colour. Moreover, damage or a tearing of the paper web can be recognised.

Furthermore, a measured parameter can relate to a characteristic value of a dryer section, and indeed for example to a surface characteristic of the dryer cylinder or of a roll. For this, the surface temperature of the cylinder or of the roll can, for example, come into question.

The measured parameter can also relate to a characteristic value of a steam system and/or condensate system of the dryer section in a paper making machine.

Moreover, a measured parameter can relate to a characteristic value of a screen used in a dryer section. For this purpose, the moisture content, the temperature, the permeability and the degree of contamination of the respective screen come into question. It is also possible to detect damage, deformations, strains and streching of the screen.

Furthermore, a measured parameter can relate to a characteristic value of the air, for example its temperature or moisture content, or to an airflow, for example its direction or speed, in the region of the respectively investigated machine section or part section.

The process data are preferably detected at least substantially uninterruptedly.

In this way a continuous monitoring and assessment of the manufacturing process is made possible which enables action to be taken at once in a manufacturing process, for example when faults arise.

The measurements take place in each measured zone with at least one measurement device which is either directly attached to the machine or to a frame or beam close to the machine. For the detection of data at a plurality of measurement locations within a measurement zone using a single measurement device, the latter can be movable relative to the machine or to the frame or beam.

The measurement device can, for example, be linearly movable or can generally have a plurality of degrees of freedom, each corresponding to a linear or rotary movement, in order to detect process data concerning a plu-

rality of individual measurement locations in a measurement zone associated with it.

The uninterrupted or continuous detection of data enables a continuous control and/or regulation of machine components in dependence on the process data, with it also being possible to act on individual machine components independently of one another. For this purpose, the process data can be supplied to an evaluation unit which monitors the manufacturing process and optionally acts on the machine components. On-line influencing of the machine or of the manufacturing process makes it possible to react at once to unpredictable changes or intended changes between different types of process, in particular for carrying out type changes of paper making machines by appropriate control or regulation of the respective machine components. Fast changes of type are in particular made possible by the invention.

In accordance with the invention the data detection can also take place at regular or irregular time intervals, in order, for example, to be able to carry out routine checks of the total machine or of individual machine sections or part sections. It is also possible to effect data detection only then when disturbances arise at the machine, in order, for example, to localise the source of disturbance by detection of the process data at measurement zones or measurement points arranged in series in the process direction. For this purpose at least one mobile measurement device can be provided which is installed to carry out the method of the invention in sequence at the individual measurement zones or measurement locations. It is fundamentally also possible to simultaneously investigate the machine, the material web and/or the environment at all measurement points or

measurement zones using a plurality of such mobile measurement devices.

In accordance with a further preferred embodiment of the invention the process data are stored in a process data bank.

The knowledge obtained concerning the respective manufacturing process or process section are in this manner not lost and can be made available to interested circles. Furthermore, external access to such banks of process data is possible, for example via the Internet, whereby remote diagnosis by the machine manufacturer is, for example, possible. Moreover, remote control or regulation of the machine or of the manufacturing process can take place from any desired location on the basis of the information which is stored in the data bank and which can be called up.

Furthermore, it is preferred when the process data can be detected in a reflection measurement process. For this, it is not necessary to use through- radiating processes to carry out measurements at the material web, which require a free run of the material web, so that the transmitter and receiver can be arranged at different sides of the material web. Measurements made using refraction methods in which the transmitter and receiver are arranged on the same side of the web do not require free runs and can also be carried out at very high web speeds in which free runs can no longer be realised. In accordance with the invention the process data relating to the material web can in each case be detected in a zone in which the material web is guided or supported, for example by a dryer screen, a roll or a cylinder.

The invention makes it possible to check and/or to regulate the longitudinal profile and/or the course of drying of the material web. This can take place by regulation of the heating curve of the drying section and/or of the individual dryer groups, dryers or humidifiers. This regulation can be effected in one or more part sections. The regulation preferably takes place continuously.

A preferred use of the invention are moisture content measurements along the dryer section. On the basis of the measured moisture content of the material web, i.e. by measuring web humidity, its transverse humidity profile, its longitudinal humidity profile and/or its drying progress can be regulated. This can, for example, takes place by regulation of the heating curve of the dryer section and/or by regulation of the individual dryer groups, dryers and/or humidifiers.

The object underlying the invention is moreover satisfied by a measurement system for carrying out the method of the invention which has at least one measurement device for the detection of process data relating to at least one measured parameter at at least one measurement point and also an evaluation unit for the joint evaluation of the process data.

The measurement system preferably includes at least one measurement device which is formed for the detection of process data at a plurality of measurement locations and for this purpose has at least two degrees of freedom, each corresponding to a rotary movement or to a linear movement, or which is rotatable about an axis. Process data can be detected at many measurement points in a short time with a single movable measurement device of this kind.

When, in accordance with a preferred variant, the measurement device is movable approximately perpendicular to the direction of web movement, machine direction or process direction for the measurement of transverse profiles of the respective measured parameter, it is possible to simultaneously obtain a plurality of transverse profiles and longitudinal profiles of the respective measured parameter by providing a plurality of such measurement devices in series in the process direction.

Further preferred embodiments of the invention are set forth in the subordinate claims, in the description and also in the drawing.

The invention will be described in the following by way of example with reference to a drawing, the single figure of which schematically shows a measurement system used at a paper making machine to carry out the method of the invention in accordance with an embodiment of the invention.

In the drawing a part of a paper making machine is shown in which a press section 20, a dryer section 10, a refinement section 22 and also a roller section 24 follow one another in the process direction P.

The dryer section and the refinement section 22 each include a plurality of part sections 14 which are symbolised by squares. In the dryer section 10 the part sections 14 can, for example, be individual dryer cylinders, groups of dryer cylinders or generally different drying systems.

Individual measurement zones 12 at which process data relating to at least one measured parameter is detected with at least one (not illustrated) measurement device are shown in the figure by hatched triangles.

One measurement device having a plurality of degrees of freedom and in particular being movable in at least one longitudinal direction, for example the machine direction, the transverse direction or the vertical direction, and also pivotable or rotatable via a joint in at least one plane is preferably provided in each measurement zone 12. One measurement zone 12 can thus be covered by a single measurement device in which the paper web, a machine component and the environment can be investigated at a plurality of individual measurement points.

In the embodiment shown in the Figure, the first three measurement zones 12 and also the fifth and seventh measurement zone 12 in the process direction are arranged beneath the respective part section 14 of the respectively machine components of the dryer section 10. The fourth and also the last measurement zone 12 are each located within a part section 14 of the dryer section 10 and can each, for example, be reached with a measurement device which is mounted at the free end of a beam which projects into the dryer section 10, for example into the intermediate space between the individual dryer cylinders. The sixth measurement zone 12 in the process direction P is located above the dryer section 10, with it being possible for the measurement device provided for carrying out the measurements at this measurement zone 12, to be mounted on a beam or frame which extends over the dryer section in the manner of a hall crane.

Each measurement device includes at least one measurement head which is designed for the detection of data relating to one measured parameter. The measurement can be carried out either at the paper making machine, at the paper web or in the environment.

In this connection some of the measurement zones 12 provided in series in the process direction P can each be provided for the measurement of the same measured parameter, for example the moisture content of the paper web, in order, in this way, to obtain a longitudinal profile of this measured parameter. Furthermore, different measurement parameters can be measured at each measurement zone 12 either with the aid of a plurality of different measurement devices or of a plurality of differently designed measurement heads which are combined to one unit or measurement device. In this manner, measurements at the paper web, at the paper making machine or in the environment can be made at each measurement zone 12.

The same also applies to the refining section 12 at which two measurement zones 12 are provided in the illustrated embodiment, with the first measurement zone 12 in the process direction P being arranged beneath the refinement section 22 and the second measurement zone 12 being located within the rear one of two part sections 14.

The measurement zones 12 located beneath and above the dryer section 10 and also the refinement section 22 are each located directly in front of or behind a part section 14 in the process direction P.

As indicated in the Figure by the arrows emerging from the measurement zones 12, the process data are supplied to a common detection unit 18 which communicates with the measurement devices arranged in the measurement zones 12.

The process data are transferred from the detection unit 18 to a common evaluation unit 16 as is indicated in the Figure by the arrow T. In the evaluation unit 16 a joint evaluation of the process data takes place in which additional parameters, such as, for example, the process speed, can also be taken into account in order to obtain, through the integrated consideration of the process data and eventually of the additional data, a picture of the state of the dryer section 10 and of the refining section 22 and also of their influence on the paper web and thus on the manufacturing process.

The detection and evaluation of the process data preferably takes place uninterruptedly in order to enable a continuous monitoring and assessment of the paper making machine or of the dryer section 10 and refining section 22. The evaluation unit 16 can be provided with a computer on which software is installed for the modelling of the manufacturing process or of the processes which take place in the dryer section 10 and in the refining section 22. The process data which reflect the actual conditions at the paper making machine can be used for the checking and optimisation of such models. In particular, when the machine is to be controlled or regulated on the basis of such models, the checking and adaptation of the models takes place in dependence on the actual process data on-line in order to realise a continuous influencing of the machine while taking account of the process data.

On the basis of the detected process data and/or of the initial data of process models, a control and/or regulation of individual machine components in the dryer section 10 and in the refining section 22 takes place, if necessary, through the evaluation unit 16, as indicated by the arrow R in the drawing. Machine components at other sections of the paper making machine at which no data which enters into the integrated consideration is detected can basically also be acted on via the evaluation unit 16.

Furthermore, the possibility exists, in accordance with the invention, of a data transfer indicated in the Figure by the arrow D to a databank for the storage of process data or via data lines, for example utilising the Internet, to external receivers. In this manner, a remote diagnosis and also remote control or regulation of the paper making machine can, for example, take place by the machine manufacturer.